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THREE-DIMENSIONAL CRACK PROBLEMS

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THREE-DIMENSIONAL CRACK PROBLEMS

Four technical reports [1,2,3,4] have been prepared under this grant. The important results will be summarized here, but for details the original reports should be read.

Surface Crack

The initial work was concerned with an improved numerical analysis of the surface crack problem [1]. The Schwartz alternating technique was used to systematically superpose the penny-shaped crack solution and the half-space solution (both for general loading) to obtain the solution for a half-space containing one-half of a penny-shaped crack at and perpendicular to the free surface. Several stress singularities were isolated and treated analytically to avoid the effect they would have had on the numerical analysis. The one singularity for which there was no analytical treatment was subjected to intense and lengthy numerical analysis to minimize errors.

The result described in [1] was that the stress intensity factor for the case of uniform pressure on the surface crack is relatively small (5% larger than for a completely embedded penny-shaped crack) at the deepest point of the crack front. The stress intensity factor increases away from the deepest point to about 23% more than the completely embedded case and then, in the last 5 to 10 degrees of arc of the crack front near the surface, drops rapidly.

Half-Plane Cracks

To complete the solution for the stress intensity factors along a half-plane crack in an infinite medium, [2] obtained the results for concentrated forces acting on the crack faces parallel to the crack front. The stress intensity factors for this case have forms similar to the case of normal and shearing force components in the plane perpendicular to the crack front.

The concentrated force solutions of [2] were used as Green's functions in [4] to analyze some problems of distributed loads applied to the half-plane crack. As described in detail in [4], these loads were chosen to simulate problems of plates with cracks whose planes are not normal to the plate.

The stress analysis in [4] is then used for an analysis of the growth by creation of new fracture surface of the cracks. The strain energy density theory described in [3,4] and their references was used to make these calculations. The results show a warped new crack surface qualitatively like some experimental observations.

Narrow Ellipses

Some two-dimensional calculations were made using the exact solution for the stress field around an elliptical hole in a uniformly stretched plate [3]. The strain energy density was computed in the neighborhood of the ends of narrow, but not sharp, ellipses. The strain energy density theory then permitted calculation of failure loads and shape of the fracture surface. One of the significant results is that the theoretical prediction agrees with experiment even after a large amount of new fracture surface has been formed. This indicates fracture rapid enough that dynamic changes in the state of stress may be considered slow.

References

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or see same authors in "Application of Papkovich-Neuber Potentials to a Crack Problem," International Journal of Solids and Structures, Vol. 9, 1973, pp.643-654.

[3] M. E. Kipp and G. C. Sih, "Strain Energy Density and Surface Layer Energy for a Crack-Like Ellipse," NASA-TR-73-3, Lehigh University, June 1973.

[4] R. J. Hartranft and G. C. Sih, "Growth Characteristics of a Plane Crack Subjected to Three-Dimensional Loading," NASA-TR-73-4, Lehigh University, July 1973.